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PRINCIPAL CONTENTS

A Study of the Inheritance of Locular Composition in Mysore-American Cotton Fruit and Its Relation to Yield—
By V. N. Ranganatha Rao.

Bee Flora of a Coffee Estate—I—
By R. L. Narasimhaswamy, M.Sc.

THE JOURNAL OF THE MYSORE AGRICULTURAL AND EXPERIMENTAL UNION

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The Journal
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Vol. XVIII] [No. 1

A Study of the Inheritance of Locular Composition in Mysore-American Cotton Fruit and Its Relation to Yield

By
V. N. Ranganatha Rao
Economic Botanist, Department of Agriculture, Mysore State

Part I

Introduction

In any scheme of plant improvement the yield factor is of primary consideration. Improvement of the crops in other directions, such as protein content in wheat, or oil content in oil-seed plants or increase in flavour in the case of fruit plants though no doubt of practical value, still is only secondary to increase in yield.

In cotton, increase in yield per acre depends upon several factors. In the first place, it depends on the number of effective bolls formed on the plant, whether such bolls are produced on the secondary or the tertiary fruiting branches, or on the extra axillary branch on the main stem; secondly, it depends on the size (both length and width) of the fruits developed. Finally, it may depend on the number of locks the fruit contains.

It is proposed in this paper to discuss, how far an increase in the number of locks in cotton fruit contributes towards the increase in yield of seed cotton per fruit, to ascertain if there is any relation in a plant between fruits developing large number of locks and the total number of effective ripening fruits and finally to find out any pronounced difference in yield between two strains of cotton whose fruits develop the same number of locks, but differ in the size of the fruit.

Material and Method of Work

The investigation was for the present restricted to two strains of Mysore–American cotton denoted by Nos. 471–3 and 320–16. Facts relating to the history and development of Mysore–American cotton in general were described in an earlier issue of this *Journal*.*

As is well known a cotton fruit generally consists of two to six parts or locks. In all Asiatic and Egyptian cottons (including Sea Island cotton) it is common to find fruits generally with 3 divisions or locks and occasionally with four divisions. On the other hand in American cottons, it is usual to find 4-lock fruits and sometimes fruits with five divisions. Bolls with either two or six parts are extremely rare.

Amongst several hundred selections made from a cross between the annual cotton *G. hirsutum* (local *Doddahatti*) and a tree-cotton *G. peruvianum*, a plant (471–3) was found in 1928–29 with very big fruits, a high proportion of which developed 5 locks. The produce of these 5-lock bolls was harvested separately for further sowing and this partly formed the material for work described in this paper.

Another plant selection 320–16 made during the 1929–30 season with smaller fruits having a large number of 5 locks was also used for investigation in this work.

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* "Mysore-American IV.—A new form of *Doddahatti* (American cotton) for our red soils," *The Journal of the Mysore Agricultural and Experimental Union*, 1924, VI (2-3), pp. 59–65.

Mysore–American cotton is grown as a partially irrigated crop on the experimental farm at Babbur, on red soil. It is generally sown about the middle of August, the seeds being dibbled with a spacing of 3 feet by 3 feet between plant and plant. To ensure proper stand two or more seeds are generally put in a hole, one healthy and well-developed seedling being retained ultimately. The plants are selfed and protected from cross-fertilization.

The investigation was mainly with reference to the following points:—

1. How far this character (*i.e.*, development of 5-lock fruits) is hereditary,
2. Does a plant developed from 4-lock fruit produce 5-lock ones,
3. What is the difference in weight of seed cotton between a 4-lock fruit and a 5-lock fruit,
4. Is there any pronounced relation between the size and yield of seed cotton in fruits having similar locular composition,
5. What is the relation between the locular composition and the number of total effective fruits per plant which ultimately affect the yield, and
6. What is the effect of climate and soil conditions on the size and the locular composition of the fruit?

Previous Work Done on this Subject

1. Lawrence Balls[1] studied this subject and arrived at the conclusion that the number of boll locks in cotton plant was inherited and that strains of Egyptian, American and hybrid cottons would be obtained and isolated, which consistently from generation to generation gave a higher or lower number of boll locks than the average.

2. Harland[2] working in West Indies on Sea Island, West Indian and American cottons has come to the conclusion that meristic characters are inherited.

3. Kearney[3] in America was able by selection in Pima cotton to develop strains with a greater number of 4-locks,

though he did not find any economic advantage in a strain having high number of locks.

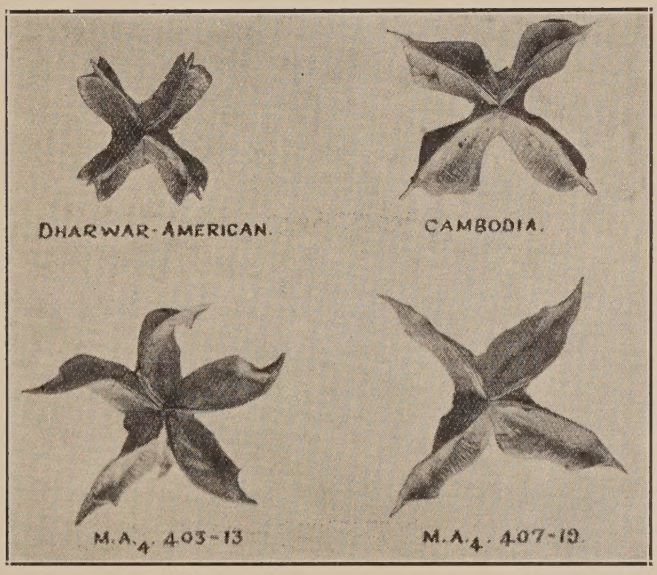
4. Dunlavy[4] in his two articles (*a*) "Frequency and importance of 5-lock bolls in cotton" arrived at the conclusion that his results were very pronounced and tended to vindicate the producer in his persistent desire for a cotton that produces a high percentage of 5-lock bolls and (*b*) (*vide* lit. cited) concluded (1) that there is very little difference between the 5-lock bolls from the same mother plant, and (2) that the 4-lock boll progeny proved to be a slightly higher producer of 5-lock bolls. His further conclusion was that the highest producing (production of 5-lock bolls) plants resulted in the highest producing progenies.

He concluded by suggesting some very useful work which might have a bearing on yield could be done to find out whether or not there is any correlation between number of bolls per plant and percentage of 5-lock bolls.

5. In India Kulkarni[5] devoted some attention to this problem. In a cross between Sea Island (*G. barbedense*) and Upland (*G. hirsutum*) he studied the inheritance of number of boll locks, and drew the conclusion that out of a splitting generation of a hybrid for this character (locular composition) in a commercial variety of cotton containing plants of low and high values of mean boll lock number, pure strains having high value of mean lock number can be easily and successfully evolved by selecting plants having high boll lock number; further he states that 4-lock bolls gave on an average 34% more seed cotton than 3-lock bolls.

Study of the Inheritance of Four- and Five-locks in the Strain 471–3 and 320–16 of Mysore–American

As already stated a plant with many 5-lock fruits was isolated in the season of 1928–29. The seeds of these fruits were harvested separately and sown in the 1929–30 season which gave rise to 124 plants out of which 102 developed well and the rest died. When a study of these 102 plants



Locks in bolls of different cottons

was made it was found that 100 of them gave rise to fruits possessing a high percentage of 5-locks and a small percentage of 4-lock fruits while the remaining two plants gave rise to only 4-lock fruits.

Seeds from 63 plants of the former and of the latter two were taken for sowing in the 1930–31 season. The progeny of the 63 plants, sown in 3 lines, gave rise to 5-lock and 4-lock fruits in various proportions; further selections being again made of plants having a high proportion of 5-lock fruits. On the other hand the progeny of the 4-lock plants of the two plants of the previous season gave rise to 5-lock fruits along with those of 4-locks. Six plants possessing a high percentage of 5-lock fruits in these were selected which ranged between 41 and 59 with insignificant number of 4-lock fruits developing.

A summarised statement is given below:—

STRAIN 471–3

1928–1929
One plant with a high percentage of 5-locks and a small percentage of 4-locks was selected

1929–1930
124 plants were raised out of which 102 well-grown were studied

Developed from 5-lock seeds	Developed from 4-lock seeds
100 gave 5-lock bolls	Two, 4-lock bolls
1930–1931	
All plants gave rise to progeny with 5-locks and 4-locks in various proportions	Gave rise to 4-locks as well as 5-locks

63 plants giving a high proportion of 5-lock bolls were selected and sown in 1931–32. These gave rise to highest number of 5-lock fruits ranging between 41 and 59 with insignificant number of 4-lock fruits

STRAIN 320–16

1929–1930
Selected a plant possessing fruits with a very high percentage of 5 locks

1930–1931
Sowed five lines with seeds of individual 5-lock and 4-lock fruits separately and selected plants giving a high number of 5-lock fruits

1931–1932
We got plants giving 5-lock fruits between 100 per cent. and 85 per cent. From plants developed from 4-lock bolls, we got progenies developing 4-locks as well as 5-locks

The conclusions that can be drawn from the above are:—

1. That the character, *viz.*, 5-locular composition of fruits is hereditary.
2. That even though we could select in a season a plant possessing the highest number of 5-locks with practically no 4-lock fruits, yet this is not heritable as in the succeeding season such plants will always have a tendency though sporadic to develop a certain number of 4-lock fruits. It appears by repeated selections the proportion of 5-lock to 4-lock may be increased.
3. Similarly in a plant possessing only 4-lock fruits we got not only 4-lock fruits in the succeeding generations but 5-lock ones also appeared in the progeny.

No conclusive results have yet been obtained with regard to (1) the relation between the size of the fruit possessing the same number of locks and the yields, and (2) the relation between the total number of fruits in the plant and the highest locular composition. Work on the above is being continued and it is hoped the results will be published in the near future.

Part II

The Difference in Weight of Seed Cotton between a Four-lock Fruit and a Five-lock Fruit

A statistical analysis of the data collected was made in order to see if the weight of seed-cotton in a 5-lock boll differs significantly from that of a 4-lock fruit and to arrive at a relationship between the number of locks and the weight of seed-cotton.

The raw data consisted of the weights of seed-cotton in each boll or fruit of 5-locks and of 4-locks, the number of bolls in each group being 80. Frequency tables of weights of seed-cotton for (1) bolls of 4-locks and (2) bolls of 5-locks employing in both the distributions, a class interval of

0·5 gram extending from 3·00 grams to 9·00 grams were constructed and the statistical constants determined. These are given in Table I.

TABLE I

Range in grams	3·00–3·50	3·50–4·00	4·00–4·50	4·50–5·00	5·00–5·50	5·50–6·00	6·00–6·50	6·50–7·00	7·00–7·50	7·50–8·00	8·00–8·50	8·50–9·00
Frequency—												
4-Lock bolls ..	2	7	7	17	23	14	3	6	1	..	..	..
5-Lock bolls ..	..	..	4	2	6	12	16	14	13	9	2	2

Total in each frequency .. 80

The mean yields and their standard deviations calculated in the usual manner are as follows:—

	(1) 4-lock bolls	(2) 5-lock bolls
Number of observations..	80 (N_4)	80 (N_5)
Mean yield in grams ..	5·1375 (M_4)	6·4937 (M_5)
Standard deviation ..	0·7816 (σ_4)	1·0124 (σ_5)

Difference in mean yield .. 1·3562

It is seen from the table that the mean yield in a 4-lock boll is 5·1375 grams and in a 5-lock boll it is 6·4937 grams. The difference in the mean yields is 1·3562 with a probable error of 0·0965. The ratio of mean yield to its probable error is 14·06. Therefore a 5-lock fruit has inherent qualities of yielding significantly more seed-cotton than a 4-lock one.

We may now collect together the statistics of the two varieties and obtain the statistical constants as above for this distribution. The mean and the standard deviation of the number of locks in the fruits from which they were derived are as follows:—

	Mean yield	Standard deviation
A. Four-lock boll ..	5·1375	0·7816
B. Five-lock boll ..	6·4937	1·0124
C. The two together ..	5·8156	1·1553

	Difference in mean yield ("D")	Probable error ("P.E.")	Ratio $\frac{\text{"D"}}{\text{"P.E."}}$
Between (A) and (C)	0·6781	0·0627	10·9
,, (B) and (C)	,,	,,	,,

The above results show again that the 5-lock fruits yield more of seed-cotton as a matter of course and not as a matter of chance. Further, the 4-lock ones yield less than the two together and this lower yield is not due to any experimental error or chance factor.

The fact that the 5-lock fruits yield decidedly more than 4-lock ones receives further emphasis by the comparison of frequency distribution of the two varieties. When we place the distributions side by side as in Table I, we observe that in the 4-lock fruits the weight of seed-cotton per fruit ranges from 3·00 to 7·50 grams, and in the case of 9 out of 80 fruits falls within the range from 3 grams to 4 grams, in which, not one of the 5-lock fruits lies. Similarly thirteen 5-lock bolls fall within the range 7·50 to 9·00 grams, whereas none of the 4-lock ones get within that range. This means to say, that if the two varieties were combined and redistributed, the 4-lock bolls definitely tend to occupy the lower or earlier ranges of the yield, whereas the 5-lock ones tend to accumulate at the higher or later ranges of the yield. Thus we see that the two distributions are quite independent and that there is no chance relationship between them. When the "goodness of fit" is calculated in the Pearsonian sense, the value of X_2 is found to be 67·15, and '*n*' being equal to 11, the value of 'P' or the probability that a different result is likely to be

obtained, corresponding to these facts, is not significant within the first four places of decimals, and it may therefore be taken to be zero. We have thus conclusive evidence again that the two varieties are distinct from each other and do not "fit" in any degree.

But it may be necessary to see how far the larger yield in a 5-lock boll can be expected as a correlated or co-existent phenomenon. The application of the biserial method for correlation gives us a convenient measure for this coefficient. This is very easily obtained in the present case as the two universes are equivalent in size, and the usual methods of numerical work result in a value 0·7362 for the correlation coefficient. It will be seen that this value is of high order and we can now on all accounts be perfectly sure that a 5-lock variety is associated with a greater yield of seed-cotton than is a 4-lock variety.

Hitherto we have considered the fruit as a unit and by the application of the above method, have come to the conclusion that a 5-lock fruit yields more than the 4-lock one. This fact could have been expected without this elaborate calculation for it is apparent that a fruit containing one lock extra should yield the appropriate amount more. But this calculation is justified for when we apply the same analysis taking the lock as a unit, we find quite different results. The original data may now be converted to express the yield per

TABLE II

Range in grams	0·7–0·8	0·8–0·9	0·9–1·0	1·0–1·1	1·1–1·2	1·2–1·3	1·3–1·4	1·4–1·5	1·5–1·6	1·6–1·7	1·7–1·8	1·8–1·9
Frequency—												
4-lock bolls ..	1	3	5	7	7	15	22	10	2	4	3	1
5-lock bolls ..	..	4	2	7	11	16	14	13	9	2	2	..

Mean yield per lock in a 4-lock fruit .. 1·2900 gm.
Probable error of such a difference .. .. 0·0323 ,,
Difference in mean yields between the two .. 0·0075 ,,
Probable error of such a difference .. .. 0·0323 ,,
Ratio of difference to its probable error .. 0·23 (insignificant)

lock by dividing the 5-lock boll yields by 5 and the 4-lock boll yields by 4. The frequency distribution so constructed, together with the mean yields in each case, is recorded in Table II, and it will be seen from it that the difference between the mean yields though existent, is negligible, and is considerably less than the probable error of such a difference.

Even when the two varieties are mixed we do not get different results; the mean yield in that case works to 1·2938 and the difference to only 0·0038, a very negligible quantity by itself as well as in comparison with its probable error. This means to say, that when the two varieties are considered with locks as units, they are not different. They behave as if they belong to one and the same variety and they are not distinguishable according to the source from which they come. When we compare the frequency distributions of the two by placing them side by side as before and judging them for the "goodness of fit", we obtain a result quite different from the one obtained in a similar circumstance before, but in agreement with the present indication. In this instance X_2 works up to 11·8400 and '*n*' being 12, the corresponding value of 'P' is 0·3755. This is a high value of the probability and goes to affirm that the two varieties are not distinct (when compared with the lock as unit) and that there cane be no difference in the yields between them. These facts are further supported when we apply the method of biserial correlation for these data. The correlation coefficient by this process is found to be 0·2230, which is of a very much poorer order when compared with the value previously obtained. There is no doubt that there is association between the two varieties tending to give greater yield per lock for the one variety as against the other.

Thus we see that when 5-lock fruits are evolved they yield more of seed-cotton than the 4-lock ones, but if we are comparing their yield merely as so much per lock, the former present no more advantage than the latter. But if in a plant both 5-lock ones and 4-lock ones could be grown, it is certainly more beneficial to grow more and more of the 5-lock

fruits, provided other things remain constant by such a control. We should only be controlling the maximum number of 5-lock fruits that can possibly be made to grow on a plant.

I am indebted to Prof. K. B. Madhava of the Mysore University and to one of his pupils, Mr. V. N. Purna Pragna, now Statistical Assistant under the Indian Central Cotton Committee, for the help rendered in working out the statistical portion of this paper.

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Bee Flora of a Coffee Estate—I

By

R. L. Narasimhaswamy, M.Sc.

Bee culture has wide possibilities in coffee estates owing to the vast bee flora available and the continuity of plants in flower almost throughout the year. Even during the period of the south-west monsoon, whenever a break occurs or on less rainy days bees move about to gather nectar and pollen from the flowers. Some of the plants often occurring in large gregarious groups have been observed to flower for a long time and are visited by a large number of bees.

In a previous article by Venkatsubbaya,* a list of garden plants whose flowers are visited by bees is given. In this

* "Some flowers visited by the Indian Honey Bee (*Apis indica*, Fabr.)—I," by N. Venkatsubbaya, F.R.H.S., *The Journal of the Mysore Agricultural and Experimental Union*, 1938, XVII, No. 2, pp. 65–72.

paper, the author has confined these studies to the flora of coffee estates with special reference to the availability of pollen and nectar for the bees, the period of the year when the plants are in bloom and the time of the day when bees visit the flowers for nectar or pollen and gives below a list of plants that commonly grow or are grown in coffee estates and which are useful as bee plants.

Crop Plants

Coffee spp.—Arabica, Robusta and other species of coffee, as every planter might have observed are visited by bees in large numbers for honey throughout the day.

Elettaria cardamomum.—This is a particularly good plant for bees. The plants begin to flower from January and the flowering period continues up to August–September. A few stray flowers may be found even in the months of November or December. The flowers produce honey and pollen. Bees visit the flowers during the morning hours in large numbers. Cardamom plants provide food for bees during the south-west monsoon period as they continue to flower during the rainy months.

Musa spp.—Plantain inflorescences are visited by bees for honey.

Shade Trees and other Plants

Salix tetrasperma.—Bakshi is used as a shade tree for cardamom. The tree produces flowers during November–December and they have been observed to be visited by bees for pollen. Bees visit the trees during morning hours.

Pterocarpus marsupium.—Honne, a shade tree for coffee, flowers during September–October. Bees visit the flowers throughout the day-time for honey and pollen. Owing to the large number of bees visiting the flowers of these trees, their humming can be heard from a considerable distance.

Dalbergia latifolia.—Beete is another shade tree for coffee. It flowers during October–November. Bees visit the flowers in large numbers during the morning hours for collection of honey.

Bischofia javanica.—*Neerale* is a common shade tree for coffee. It flowers during February–March. The bees visit the flowers for pollen and honey during the day-time.

Terminalia bellerica.—*Tare* is yet another shade tree that is commonly grown. It flowers during February-April and is visited by bees in large numbers for honey during the morning hours. The flowers have a smell much like that of honey and can be scented from a distance.

Terminalia paniculata.—The trees flower during October–November. Bees visit the flowers during early morning hours.

Eugenia jambolana.—The trees flower during February–March. Bees visit the flowers during morning hours for honey and pollen.

Spondias mangifera.—The trees flower during February and the flowers are visited throughout the day-time by bees in large number.

Nothopegia colebrookiana.—The trees flower during February–March. The flowers are visited by bees during morning hours only.

Holigarna grahami.—The trees flower during January–February. Bees visit the flowers for pollen throughout the day.

Litsea stocksii and *Litsea wightiana* are trees which produce a profusion of flowers during October–November. The flowers have a plentiful supply of honey and pollen. It is a sight to see the swarms of bees visiting these flowers with their humming noise. Bees visit the flowers only during morning hours.

Wendlandia notoniana.—A shrubby plant; it flowers during February. The flowers are visited by bees during all hours of the day for honey.

Scutia indica.—This shrub flowers during January–February and the flowers are visited by bees throughout the day for honey.

Strobilanthes heyneanus, S. barbatus, S. ixiocephalus.—These species of *Strobilanthes* are excellent bee plants. The flowers of these plants are visited both by rock bees and honey bees in swarms throughout day-time. *Strobilanthes heyneanus* is said to flower "apparently annually"; *Strobilanthes barbatus* is said to flower once in seven years; and *Strobilanthes ixiocephalus* is said to flower "annually" or "once in seven years".† Detailed observations are necessary to state definitely whether these species flower annually or septennially.

Leucæna glauca.—This is a leguminous plant sometimes cultivated as a green manure plant. It flowers from September to January or February and again, from April to May or June. The flowers contain large quantities of pollen. Bees visit the flowers throughout the day and collect pollen.

Weeds

Datura sp.—These plants grow in waste places and produce large bell-shaped flowers which have plenty of honey stored inside the corolla tube. Bees visit the flowers during morning hours.

Some varieties of roses have been observed to be visited by bees.

Smithia sensitiva and *Polygonum chinense* are two species which grow profusely in marshy places. They flower during October–January. The flowers are visited by bees during morning hours.

Bidens pilosa.—This is a common gregarious weed in coffee estates. It is observed to begin flowering from the latter part of the south-west monsoon and continue to flower for a long time—even until January or February if not removed. It is a very good bee plant, its flowers being visited by bees in large numbers throughout the day. The flowers provide pollen for the bees.

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† "Flora of the Presidency of Bombay," by Theodore Cooke, C.I.E., etc., July 1905, II, Part II, pp. 366–273.

Gynura angulosa and *Aegeratum conyzoides* are two species which are also common gregarious weeds in coffee estates. They begin and continue to flower from the middle of August to January or February, if left undisturbed. Again, they begin to flower after the first rains in March or April and continue to flower up to the end of May or June. Bees visit the flowers in large numbers throughout the day and collect pollen.

Mimosa pudica.—The sensitive plant is another common weed much visited by bees. The flowering season of the species extends from August up to February and again from after the first rains in March or April up to the end of May or June.

Though the plants—*Bidens pilosa, Gynura angulosa, Aegeratum conyzoides* and *Mimosa pudica*—are generally treated as weeds on coffee estates and hence their removal is desirable, it is not possible to destroy them completely. As a result these plants may be found at any time in or around coffee estates serving as useful bee plants.

Brief as the list is, it indicates that some of the plants that are of use as shade trees are also of use as good bee plants. Planters, therefore, need not concern themselves with growing plants separately to provide bees with food. Further, it will be observed that there is a succession of plants producing flowers throughout the year and at no time is there a complete absence of blossom. The observations recorded here are only of a preliminary character and it is hoped to continue the study of the bee flora when time permits.

In conclusion the writer wishes to express his thanks to Mr. N. Venkatasubbaya, for having induced him to take an interest in the study of bee flora.

Proceedings of the Nineteenth Field-Day and Annual General Meeting of the Mysore Agricultural and Experimental Union, held at Mandya, on the 17th December 1938

The Field-Day of the Mysore Agricultural and Experimental Union was held in the morning when the members were shown round the Irwin Canal Farm. At 12 noon dinner was served.

The Annual General Meeting was held at the 'Jayachamaraja Wadiyar Town Hall', Mandya, at 3-30 p.m. A number of invitees and members were present. In the absence of the President, Mr. T. G. Rama Iyer, Mr. B. Venkatanaranappa, the Vice-President, presided. After reading the President's letter regretting inability to attend the meeting, the Vice-President in his opening remarks enumerated some reasons for Agricultural backwardness in the country owing to the existing mutual distrust and a disinclination of the educated men to favour agriculture; and stressed the necessity for the combination of a few people to form an association at Mandya.

The Secretary then read the welcome address (published elsewhere).

After the distribution of *pan-supari* to those present the General Meeting came to a close.

The Business Meeting commenced with Mr. B. Venkatanaranappa in the Chair. About 35 members were present. After the adoption of the Progress Report and the Statement of Account for the year ending 30th June 1938, the Vice-President moved from the Chair the following resolutions which were passed *nem con*:—

Resolved:

1. "That this meeting of the members of the Mysore Agricultural and Experimental Union desires to convey to the Government of His Highness the Maharaja of Mysore through the Director of Agriculture in Mysore its deep sense of gratitude for the continued interest they are evincing

in the work of the Union by granting an annual subvention towards the expenses of the Union.

2. "That the Government of His Highness the Maharaja of Mysore be requested through the Director of Agriculture, kindly to continue their support to the Union by granting an annual subvention of Rs. 2,500 (Two thousand five hundred) only, for a further period of at least five years.

3. "That this meeting of the members of the Union desires to convey to the Director of Public Instruction its deep sense of gratitude for his kind patronage and requests that subscription by Middle Schools to the Kannada Journal of the Union may be made compulsory.

4. "That the Revenue Commissioner be requested to arrange for the purchase and distribution of copies of the Kannada Journal among the Village Panchayats.

5. "That the Director of Agriculture be requested to take such steps as are necessary for the furtherance of the objects of the Union.

6. "That a branch of the Union be formed at Mandya for the benefit of the local raiyats.

7. "That the valuable services rendered to the Union as the Chief Editor of the English Journal by Dr. Venkata Rao K. Badami, L.Ag., Ph.D. (Cantab.), the former Deputy Director of Agriculture, Mysore State, be placed on record."

The following gentlemen were then elected to the Managing Committee:—

1. Mr. T. G. Rama Iyer, B.A. (*President*).
2. „ B. Venkatanaranappa, M.A. (*Vice-President*).
3. „ S. Venkataswamy Gowda
4. „ M. J. Narasimhan, B.A.
5. „ M. S. Ramachandra Rao, B.A., B.L.
6. „ B. Shankara Rao Badami, M.A.
7. „ G. Venkataramaniah
8. Col. C. B. Oakley, V.D., A.M.I.M.E.
9. Mr. T. S. Raghavachar, B.A.

10. Mr. T. Lakshmana Reddy
11. „ Mysore Mahalingappa
12. „ N. Venkatasubbaya, F.R.H.S. (Secretary).

After vote of thanks by the Secretary, the meeting terminated.

Secretary's Welcome Address

I have very great pleasure in inviting you all to the 19th Annual General Meeting of the Mysore Agricultural and Experimental Union.

As the General Meeting of the Union is being held at Mandya for the first time, it may not be out of place if the object and functions of the Union are stated briefly for the benefit of local agriculturists. The Union was organised 20 years ago with the object of bringing together the trained agriculturists of the Mysore Agricultural School, other agriculturists engaged in farming and the members of the staff of the Mysore Agricultural Department for the purpose of developing the agriculture of the State. Among the Union's main functions has been the carrying out of correct field-experiments of the various recommendations made by the local Agricultural Department with a view to ascertaining how far they are real improvements under the varying soil and climatic conditions obtaining in the country.

Looked at from the standpoint of the objects and functions of the Union, it seems very appropriate that one of our annual functions should be held in this town of Mandya, which will very soon be the headquarters of a district with chances of ever-increasing prosperity. Hardly a decade ago this area was typical of a barren and desolate countryside with a poverty-stricken and debt-laden ryot population. With the advent of the Irwin Canal and an assured water supply the appearance of the country has been completely changed from one of desolateness to one of prosperity as though the change has been wrought overnight under the influence of magic wand. The resulting prosperity is evident; the magician is not apparent but the wand continues to exert its influence. One of the largest

scientific experiments on farming ever conducted in this country is in the Irwin Canal area. The agricultural methods in vogue in the irrigated area of this tract are the ones approved by scientific experiment. Before any kind of farming suitable for the area was determined an extensive soil survey was conducted. Soils were classified for their suitability to various kinds of farming. A rotation of crops to be followed was devised with a view to building up a prosperous agricultural industry without sacrificing the health of the population. The varieties of crops and methods of cultivation and manuring introduced were the most approved with the result that the farming in the area is of a very high standard. One of the results of this huge experiment is the Mysore Sugar Factory. It is therefore quite appropriate that the Annual Meeting of the Mysore Agricultural and Experimental Union should be held here in the midst of such notable examples of what science can accomplish when properly applied to crop production.

The Union being a body composed of working farmers has confined itself to its main activity, *viz.*, the conducting of small-scale trials of improvements recommended by the Agricultural Department. Varieties of improved crops like ragi, sugarcane, groundnut and cotton have been tried by the members and the results have been of great value to the Department in introducing the most suitable variety for each locality. Members have conducted trials of improved implements designed by the Department and furnished results which have been useful in modifying them according to requirements of varying soils. The Mysore Plough, and the New Seed-Drill were tried by members of the Union on their land and reported upon before the final product was put on the market for sale. Members have also conducted trials of manures, spraying of crops against fungus diseases and methods of controlling insect pests, &c., and furnished valuable information. During the year 1937–38, they conducted experiments on new varieties of ragi, groundnut, cotton and paddy, manurial trials, test of the new seed-drill, control methods of the sugarcane borer, pests of stored

paddy and the lime-tree borer. The results have not all been received but those that are, will be discussed at our business meeting and published in our Journal in due course.

The scope for small-scale experiments of improvements recommended by the Department is very vast. The need for accurate results as to how far the recommendations are real improvements is quite urgent as extensive demonstrations must be based on the results of these local trials. The Irwin Canal area with its assured supply of irrigation water offers the most favourable conditions for the trials of recommended improvements under irrigated conditions. Is it too much to expect the enterprising farmers of this area to join our band of experimenters and share with us the glory of assisting in the building of a prosperous farming industry?

The Union has been publishing an English Quarterly and Kannada Monthly Journal for the past several years for the purpose mainly of instilling into the minds of its members and its readers the experimental attitude of mind. It publishes in these Journals the results of experiments conducted by the State Department of Agriculture and other Indian and foreign departments of Agriculture in so far as they might be valuable to this country. Prominent place is usually given in these Journals to members' work. As the demand for knowledge increases and as this demand is felt by the management in terms of incoming money the Journals will be made more and more useful and instructive. The many volumes of these Journals already published contain a wealth of knowledge on practically all the aspects of the application of science to farming practice. The management have recently decided to publish selected articles from these Journals in book-form so as to furnish a reference book to every one who wants a book dealing in agricultural and related subjects in Kannada.

The Union is convinced that 'Agriculture is the hope of the Nation' and has been working for the betterment of rural life through the development of this basic industry. This work has been made possible by the continued interest which the Government of His Highness the Maharaja of Mysore

have been evincing in its work. They meet the larger part of its expenses by granting an annual subvention. Should the usefulness of the Union increase at all, more funds are necessary. In these days of reorganization of rural life, accurate information on matters connected with the basic rural industry—Agriculture—is very necessary for all those engaged in rural development. Such information is provided in the columns of our Kannada Journal. Village Panchayats which are engaged in development work cannot find a surer source of information than our Kannada Journal.

Complaint is often made that the education given in the schools of rural parts is not designed to satisfy rural needs. In recognition of this fact our State Department of Education has provided in selected Middle Schools situated in rural parts, for instruction in what is known as "Rural Science". The instruction imparted in these schools is expected to create in the minds of the pupils a rural bias. In this country of villages, one feels some time, that the 'rural bias' must be created in practically all Middle Schools. Whether this is practicable or not, cannot the middle schools serve as centres from which knowledge essential to rural life will spread? Through the good offices of the Head of the Department of Public Instruction, the Union was able to enlist a large number of Middle Schools as subscribers to its Kannada Journal. A large number of these schools are however discontinuing to subscribe for a copy as the desire to cater to the demands of topical news seems to preponderate other more essential though less apparent requirements.

Before concluding this report, a word in fine. It is our duty to place on record the valuable services rendered as our life-member and Chief Editor of the Quarterly English Journal by Dr. V. K. Badami, who is now raised to an eminent position in one of the Indian Provinces.

N. VENKATASUBBAYA,
Secretary.

Statement of Receipts and Expenditure from 1st July 1937 to 30th June 1938

(as submitted to the Comptroller)

Receipts	Rs.	A.	P.	Expenditure	Rs.	A.	P.
Opening Balance	823	2	3	Establishment for 12 months ..	1,614	10	9
Admission Fee	27	0	0	Press Bills Paid	1,168	13	6
Membership Fee	294	14	0	Postage	59	14	0
Subscription	720	10	0	Miscellaneous (Contingencies) ..	81	8	9
Miscellaneous Receipts	53	14	0				
Subvention for 1936–37	2,000	0	0				
Total ..	3,919	8	3	Total ..	2,924	15	0
				Closing Balance ..	994	9	3
Grand Total ..	3,919	8	3	Grand Total ..	3,919	8	3
Forecasts of Pending Expenditure—							
1. Establishment for June 1938 ..	136	0	0				
2. Press Bills pending payment ..	103	10	0				
3. Cost of printing June issue of Kannada Journal	60	0	0				
4. Cost of printing Vol. 17, Nos. 3 & 4; and Vol. 18, Nos. 1 & 2, of English Journal	600	0	0				
Total .	899	10	0				

N. Venkatasubbaya, *Secretary.*

Experiments

Particulars	1937	1938
Number of membes conducting Expeiiments..	8	8
Number of Experiments conducted	15	24*
**Details of Experiments*		
Experiments with improved seeds ..		16
Manurial experiments		2
Control of Insect Pests		4
Experiments with improved implements, *viz.*, The new Seed-Drill		2

SELECTIONS

Objectives of the Experiment Station

1. To reduce the cost of producing farm crops and live-stock through the development of more efficient methods. Under this objective fall such investigations as the control of injurious insects and diseases, improvements in cultural practices, farm management studies and experiments on plant and animal feeding.

2. To improve the quality and marketability of farm produce. Here are included the breeding of better varieties of crops and types of live-stock, and studies of grades and packing.

3. To expand the uses and to find new outlets for farm products. Under this objective are the studies of consumer demand, marketing procedure and possible industrial uses for farm products.

4. To conserve the land and water resources of Pennsylvania. This always has been a major objective of the Experiment Station. Here are included all the studies of soil fertility and plant nutrition which have been in progress since the Experiment Station was organized, together with soil surveys, and studies of soil erosion, land-use planning and wild-life.

5. To promote a satisfying rural life. The investigations included here are concerned primarily with home making in the country—the public agencies and social institutions of the country, changes in standards of living on the farm, home economics and human nutrition, migration between the cities and the country, and part-time farming.

6. To advance the boundaries of knowledge of the sciences which enter into the practice of agriculture. This so-called fundamental research, as distinct from experiments having immediate practical application, is the foundation of progress in agriculture.

—50th Annual Report of the Pennsylvania State College School of Agriculture & Experiment Station.

Farm Yard Manure

Farm yard manure is a composite organic manure—it consists mainly of the solid and liquid fæces of animals intimately mixed with the litter or bedding supplied to the animals. It not only supplies all the four nutrients that a normal soil might lack, *viz.*, Nitrogen, Phosphoric Acid, Potash and Lime, but it contributes what no inorganic fertilizer can supply—the elixir of sick soils—humus.

The quantity of farm yard manure is very variable indeed, but 1,000 lbs. of a good average sample should supply approximately 5 lbs. Nitrogen, 3½ lbs. Phosphoric Acid and 5 lbs. Potash. In such a sample two-thirds of the total Nitrogen and nearly all the Potash would be supplied by the liquid fæces—while the solid fæces would contribute nearly all the Phosphoric Acid and Lime. The bedding and straw being important in the role of absorbents.

The quantity of farm yard manure will vary with:—

(*a*) the type of animals that supply the fæces;
(*b*) the food fed to such animals;
(*c*) the work done by the animals; and
(*d*) most important of all, the methods of storing employed.

It is this factor which determines to a great extent the fertilizer value of our farm yard manure and without doubt there is much room for improvement in this regard on the large majority of our farms.

Any attempt at producing good farm yard manure, should aim at the elimination of the following deteriorating agencies:—

(i) Draining away of liquid portion of manure.
(ii) Dilution of the manure heap by rain, etc.
(iii) Leaching of liquid manure through a pervious floor.
(iv) Evaporation of volatile constituents of the manure heap.

We have seen that the liquid fæces alone in an average sample of farm yard manure are responsible for two-thirds of the total Nitrogen and nearly all the Potash. The following figures worked out by the German authority Wolffe will illustrate this point more clearly:—

Animal	Water lb.	Nitrogen lb.	Phosphoric acid lb.	Potash, lime, etc. lb.
1,000 lbs. Fresh Dung Contain :				
Horse	760	5·0	3·5	3·0
Cow	840	3·0	2·5	1·0
Pigs	800	6·0	4·5	5·0
Sheep	580	7·5	6·0	3·0
1,000 lbs. Fresh Urine Contain :				
Horse	890	12·0	..	15·0
Cow	920	8·0	..	14·0
Pigs	975	3·0	1·25	2·0
Sheep	865	14·0	0·5	20·0

The loss of 1 lb. of urine is, therefore, a far more serious matter than the loss of 1 lb. of dung, and no pains should be spared to ensure that none of this precious liquid goes to waste neither by dilution and surface drainings nor by downward percolation. Your manure heap should have a good roof, a floor that allows the minimum of percolation and should be so built that there is no risk of dilution or loss.

At present it is the exception rather than the general rule to find a manure heap that does not smell of Ammonia. A smell of Ammonia from your manure heap indicates a continuous loss of nitrogen by evaporation. Such loss is usually caused by a rise in temperature in the heap itself occasioned by:—

(i) Too little liquid in the heap.

(ii) Non-absorption of the liquid portion of your manure by the use of an insufficient supply of litter.

Control of these factors and consequent prevention is the best treatment but the addition of chemicals (*e.g.,* Super-Phosphate—1 lb. per animal daily) evenly distributed will be found an efficient cure and will at the same time increase the value of the manure as a Phosphatic fertilizer.

When we consider that a well-fed cow produces approximately 9 tons of solid and 3½ tons of liquid manure per annum, we will appreciate that the annual wastage of valuable plant food in this country must reach alarming proportions.

In these days of stern competition, farmers can only win out if they adopt methods to ensure the most economical production of their crops and without doubt in the war on waste one of our major fronts will be protected if farmers will realise that artificial fertilizers can be regarded not as satisfactory substitutes for, but merely as supplementary to farm yard manure.

—Abstracted from *The Journal of the Jamaica Agricultural Society,* Vol. XLI, No. 12.

The Ethylene Treatment of Tobacco

The effect of very small quantities of ethylene on the ripening (colouring) of fruits is well known, and this gas is now being employed on a commercial scale in the United States, the Union of South Africa, and elsewhere, particularly in connection with citrus fruits. The effect of the gas on the ripening of fruits is recognised to be due to stimulation of the enzyme processes, and, since the changes which take place during the curing of tobacco are also related to enzyme action, it has been suggested that the quality of the leaf might also be fabourably influenced by the action of ethylene. Hitherto, not much

work has been done in this direction, but the matter has been taken up by the Agricultural Adviser to the Colonial Office and arrangements are being made for experiments on the gas treatment of tobacco to be carried out in certain tobacco-producing countries in the Empire. For the benefits of those concerned with such experiments the Imperial Institute has prepared summaries of two papers dealing with work on these lines which has already been done in Germany and Italy, and these are printed below.

The results of the German experiments are recorded in a paper by Dr. G. Pfüster and Dr. H. Losch, published in *Die Umschau*, Vol. 39, No. 11, March 10, 1935, pp. 202–06. The authors undertook experiments with tobacco primarily with a view to ascertaining whether a good ripe yellow colour could be obtained with certainty by means of very small quantities of ethylene or acetylene. They found that the ripening of tobacco could be accelerated by the same substances as are effective in the case of fruits, and that these include, in particular "narcotic" gases such as ethylene, acetylene and nitrous oxide. These gases can be used in very high dilution, *e.g.*, ethylene in the proportion of 1 in 1,000, or 1 in 100,000, or in some cases 1 in 1,000,000 parts of air has a definite effect on enzyme action in plant cells. Such minute traces obviously can have no deleterious effect on the tobacco or on the health of the smoker. Their action may be regarded as similar to that of an activator in catalysis.

In the authors' experiments ethylene-air mixtures in the proportions 1 in 5,000 to 1 in 10,000 were generally employed; sometimes rather more concentrated acetylene-air mixtures were used.

In order to carry out tests the freshly gathered leaves were divided into three portions, two of which were placed in air-tight chambers into one of which the gas was admitted, whilst the third went into the tobacco shed. Conditions in the two chambers were the same, temperature being between 20° C. and 25° C. and atmospheric humidity about 90 per cent. They were "aired" each day to remove carbon-dioxide which would retard the ripening process, a fresh dose of ethylene being admitted each time to the treatment chamber. Later an arrangement was devised for removing the carbon dioxide continuously by means of a rotary pump and suitable absorbent materials, this having the additional advantage of ensuring circulation in the atmosphere of the chamber.

It was found that in the case of leaves picked at the normal time or 8 to 10 days earlier, those treated with gas showed a yellow colouring earlier and more strongly than those in the other chamber, the leaves in the tobacco shed being the slowest to show any yellowing at all. Leaves that had been picked 3 weeks before the normal

time would not develop a good yellow colour, even in the gas chamber, but turned to olive-green or brown tints.

Tests of treated and untreated tobacco (after fermentation) for smoking qualities (flavour and aroma) showed every marked superiority in the case of the treated material. Thus the flavour of an untreated sample was described as "sharp and poor"* (beissend und leer) and its aroma as "not quite pure" (nicht ganz rein), whilst in the case of the corresponding treated material the flavour was pronounced "rather full, not unpleasant" (etwas coll, fast angenehm) and the aroma "pure, somewhat flowery" rein, etwas blumig). The "Character" of the tobacco in respect of those qualities that determine its gradation from "heavy" to "light" was in general unaffected by the gas, though in some cases it was rendered definitely "lighter".

The influence of ethylene treatment on nicotine content was found to depend on its duration, the first effect being to produce an increase but the final result being decrease. The authors do not attempt to correlate smoking qualities and nicotine content, but state that in their investigations the greatest improvement in quality by gas treatment did not coincide with the maximum reduction in nicotine content.

Experiments were also carried out in exposing the leaf to ethylene during fermentation, the gas being introduced either in one dose or in successive doses at intervals of a few days. The treatment has a markedly favourable effect on the flavour and aroma of the tobacco which were described respectively as "pure and full" (rein and voll) and "pleasant, somewhat flowery" (angenehm, etwas blumig), whilst the corresponding reports on untreated tobacco were "rather unpleasant and poor" (etwas unangenehm und leer) and "rather impure" (ziemlich unrein). It thus appears that gas treatment during fermentation is as advantageous as that of the freshly gathered leaves.

The effect of prolonged gas treatment was tried with a view to ascertaining whether it would be possible by this means to dispense with fermentation. Leaves exposed to ethylene (1 in 5,000) for six months and not fermented were actually judged more favourably as to smoking qualities than untreated but fermented leaves. In practice, treatment requiring such long duration would not show any advantage over fermentation as ordinarily carried out, but the result is regarded as theoretically interesting.

Finally, the authors find that even finished tobacco goods, *i.e.*, pipe tobacco, cigarettes and cigars, especially those of poor quality, may be improved in aroma and flavour (if only to a very moderate degree), by gas treatment, showing that the activity of the enzyme is

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* In view of the difficulty of translating exactly the terms used in describing smoking qualities, the German words are added in brackets.

not quite destroyed even in tobacco that has been fermented, heated, and dried in storage.

The results of preliminary experiments carried out by Dr. U. Rossi in Italy are described in the *Bollettino Technico del R. Istituto Sperimentale per le Coltivazioni dei Tabacchi "Leonardo Angeloni," Scafati* (*Salerno*), Vol. 30, No. 4, October-December 1933, pp. 221–58. The author states that ethylene gas, at suitable dilution and under proper conditions of temperature and moisture, exerts a stimulant action on tobacco leaves resulting in a considerable acceleration of the various changes that follow their harvesting. Trials made with a number of different varieties of tobacco showed that the time necessary for curing may be reduced, in general, by about 40 per cent. He claims that ethylene treatment improves the aroma, colour and burning qualities of tobacco. The gas does not itself enter into any chemical combination in the leaf, nor does the treatment lead to any secondary reactions having adverse effects on the finished product.

It is pointed out that the process is not only advantageous for improving the quality of poor tobacco. In the case of highly priced oriental tobaccos, the youngest leaves of which do not reach maturity at the required time, the ethylene treatment of these leaves, provided they have attained a sufficient degree of development, will bring them to maturity and enable them to be cured satisfactorily. It is also of special value in the case of late ripening varieties of tobacco such as Maryland, which under some climatic conditions barely succeed in reaching the stage of maturity necessary for commercial utilisation. There again, the plant must have arrived at a certain degree of development in order that the treatment may be effective.

It is also claimed that ethylene treatment, by maintaining the turgidity of the cells, decreases the rate of drying of the leaf and so reduces the risk of "green" drying when the weather is exceptionally dry or windy.

Finally, the stimulating effect of the gas on the enzyme actions continues for some time after its application has ceased, so that all those further changes that take place between the curing and the finished product are completed in a shorter time than would otherwise be the case.

The author makes the following recommendations for carrying out the process:—

The chamber used should be of ample size to allow ready access to all the material to be treated. The temperature should be between 21° C. and 28° C. and should be kept as steady as possible. If the temperature is too low the removal of the chlorophyll is inhibited, and at 15° C. the transformation of the green leaf is almost completely arrested. The precise optimum temperature is different for different varieties of

tobacco, being in general that best adapted for the natural growth of the plant. The air in the chamber should be kept changed in order to remove carbon-dioxide and any other objectionable products of decomposition. The atmospheric humidity should be maintained between 75 per cent. and 80 per cent. In order that the treatment may be effective the leaves must have reached a stage of development at least nearly approaching physiological maturity. It is also desirable that they should not have been harvested following heavy rain.

—*Bulletin of the Imperial Institute,* Vol. 35, No. 3.

Practical Composting

(A Plea for Adapting the Technique to the Raw Material and Environment)

BY

G. B. Masefield, M.A. (Oxon,), A.I.C.T.A.

Agricultural Officer, Uganda Protectorate

The subject of making compost manures has received a good deal of attention lately, and a number of excellent accounts have been published describing systems of composting. The danger of these methods is that they tend to become too systematic; and as one who has had experience of composting under varied climatic conditions, I feel that a word of warning against this tendency is desirable.

It is evident that composting cannot satisfactorily be reduced to rule-of-thumb methods. A system which is advocated for one place may be of little use in another with a different climate, and even from one season to another, with differences in rainfall, the same system will not prove satisfactory. For this reason, all systems which give a "time-table" of composting operations are to some extent a snare and delusion. The experienced composter will vary his methods from season to season and even from day to day. This is one reason why, to get the best results in large-scale composting, it is essential to have adequate expert supervision and not to rely upon unskilled native labourers only.

Pits or Heaps?

As an example of the need for flexibility, we may quote the much-vexed question of whether compost is best made in pits or in heaps. Pits are of course best under dry conditions, as the evaporation is much reduced; but they fail in wet climates or seasons. I have seen compost made in concrete pits without any provision for drainage; in a very wet season, there was standing water in the pits and the lower layers of the compost putrified and became noxious. On the other hand, in very dry weather heaps may become so dried out that

decomposition almost ceases and some of the material is actually blown away.

There are, of course, means of getting round both these disadvantages. I have made successful compost with garden refuse in a pit, the floor of which sloped down slightly to a drainage channel at one end. During a very wet season in Uganda, the rainfall just served to decompose the compost nicely without any addition of water, and the compost never became water-logged.

Heaps, on the other hand, can be conveniently protected from evaporation during dry weather by laying a few cocoanut palm leaves along the top to form a thatch. During the wet season a good idea is to build them with the top sloping inwards to a central hollow so that all rain water is caught and collected. Whether compost is best made under a roof or in the open depends on the climate, and also on whether the water-supply is sufficient to compensate for the rain lost by using a roof.

An experienced composter again will vary the size of his heaps, building them bigger in dry weather and smaller in wet. Another factor in which flexibility is desirable is the frequency of turning. In dry weather, excessively frequent turning leads to far too much loss of moisture. As an extreme example, I may quote an experiment in which two compost heaps were built, each containing at the outset 9 cwt. of fresh material. The experiment ran for 3½ months, during which one heap was turned weekly and the other not at all. At the end of that period, the unturned heap weighed 8 cwt., but the turned heap only 3 cwt.

This matter of control of moisture-content is probably the most important single factor for success in composting, and too much insistence cannot be laid on frequent visits to the compost heaps and a flexible system which will take advantage of weather conditions.

The Fly Menace

Another point to which great attention must be paid is the control of fly breeding in the compost. In most composts a sufficiently high temperature is reached in the interior of the heap to kill fly eggs and maggots. But the material at the edges does not reach this temperature, and therefore periodical turnings are necessary to ensure that this material is mixed up in the centre of the heap. In the case of the common house-fly, which is probably the commonest breeder in compost, the period from the laying of the egg to the emergence of the fly averages about 12 days in the tropics. It is therefore essential that the heaps should be turned at least every 10 days as long as the compost is fresh enough to attract egg-laying flies.

In any locality, it may be found that other species of flies are commonly breeding in compost. For example, in Trinidad *Leptocera ferruginata, Chrysomyza ani,* and an unidentified Tachinid fly were found to be of very common occurrence. Where this is so, the length of time from egg to emergence for each species should be ascertained and the turning programme arranged accordingly.

Since flies breeding in compost may become a serious nuisance and in some cases a menace to the health of people or livestock, this is another reason for insisting that operations such as the turning of compost should be under responsible supervision. For the same reason, composting cannot be altogether recommended as an occupation for uneducated native peasants.

Materials for Composting

In examining the suitability of different materials for composting, the chief consideration is to get the right degree of aeration in the mass. For example, maize stover, for composting is better chaffed than uncut; but the chaff cutter should not be set to cut too short, as this again leads to excessive compaction in the heap. Sugarcane tops, being shorter, may be composted without chopping up. Rice straw, if composted by itself, becomes too compact and does not decompose, but it will rot well if mixed with other materials. Pea and bean haulm are rather too open for composting by themselves, but are a good lightener for cereal straws. In composting garden refuse, care should be taken not to include too high a proportion of lawn-mower cuttings, as these tend to compact themselves and lead to anaerobic fermentation and acidity. Weeds are difficult to decompose if too much earth is included with their roots; but Beckley has overcome this difficulty by growing beans on the compost heaps, which assists rotting.

In general, it may be said that there are few types of agricultural refuse which cannot be composted if the right degree of aeration is obtained. Probably all of them rot better if mixed with other suitable ingredients than in the pure state, a fact which seems to have been too much overlooked in estate methods of composting. One of the exceptions seems to be tobacco stalks, which are very hard to induce to decompose. I have also had poor results with plantain leaves and peelings, both of which are a common type of habitation refuse in Uganda.

In cases where adequate aeration of the compacted mass is hard to obtain, this may be achieved artificially by placing ventilating tiles or lengths of bamboo pole under the heaps. Here again there is plenty of scope for ingenuity and flexibility of programme.

Experiments on Composting

The technique of composting experiments has its own difficulties, which make it very hard to obtain results that are convincing to the modern statistically-trained critic. In a series of experiments carried out in Trinidad at the Imperial College of Tropical Agriculture on the effect of adding various substances such as dung, sulphate of ammonia, lime, and in inoculum of "activated compost" to composts with the object of accelerating decomposition, no results were obtained which reached statistical significance as to the benefit of any of these treatments.

One reason for this position is the difficulty of obtaining from a large and often heterogeneous mass of compost a small sample for chemical analysis which shall be representative of the whole. The statistically-minded may be interested to note that on two occasions when taking six samples from the same point in the same heap for measurement of carbon dioxide evolution, the sampling error proved to be 190 per cent. and 227 per cent. of the mean respectively.

Another difficulty lies in finding a suitable means of measuring rates of decomposition. After some experience in endeavouring to assess this by such methods as temperature records, chemical analyses, degree of humification, carbon dioxide evolution, and fungus and bacterial counts, I have come to the conclusion that there is no better criterion than judgment by eye and hand. A very useful technique is to take a few fibres from the compost mass in one's hand and roughly feel the breaking strain, by which means one soon becomes quite proficient in judging the degree of rotting. Eye and hand can take in the whole of the heap in a way in which sampling methods cannot, and can often deliver a judgment which cannot be translated into figures.

Although it appears therefore that experiments in composting are apt to be disappointing, I think that there is a danger in the fact that most of the writers who have advocated different systems of composting have worked these out quite empirically, have not compared them side by side with other systems which have proved good, and have not investigated a number of variations which might have greatly improved the process. It seems desirable that a much greater number of field trials in composting methods should be made, which may at present be of great assistance to the practical man, but from which accurate scientific results should not be looked for too soon. In estate practice, it is better for every composter to make his own experiments rather than to follow too slavishly methods which have been worked out for other localities and climates.

—*Tropical Agriculture,* Vol. XVI, No. 5.

Utility of Soil-Inverting Ploughs and Improved Implements as compared with Indigenous Implements

The Royal Commission on Agriculture in India, in Para 107 of their Report, after discussing the subject-matter of this article at considerable length, remark as follows:—

> "It is clear that the only method by which the superiority of any one of them can be established is by series of careful experiments carried out over a term of years. It is eminently desirable that further attention should be given to this subject on which evidence based on experiments is lacking."

Although the Commission were apparently unaware of the fact, the subject had already received some attention from the Deputy Director of Agriculture, Cawnpore, as in the *Agricultural Journal of India,* Vol. XXIV, Part I, this officer describes an experiment started by him in the year 1922 to discover if the use of soil-inverting ploughs gave increased yields. As a result of his six years' work at Cawnpore he states that "The average percentage increase in out-turn of wheat grain and straw, assuming the yield from shallow ploughing without inversion to be 100, is as follows:—

	Per cent.
Deep ploughing with inversion ..	45
Shallow ploughing with inversion ..	33
Deep ploughing without inversion ..	13

Again, I find from the records of the Lyallpur Farm that a somewhat similar experiment was carried out there in the early days of the Department; but the results obtained in this case did not indicate any yield-superiority in favour of soil-inverting ploughs.

These conflicting results obtained at two different centres may have been due to differences in the climatic condition and soils of the two places. The heavier rainfall at Cawnpore (36 inches) would encourage the growth of weeds, so a soil-inverting plough would be more effective for keeping them in check; whilst owing to the low rainfall at Lyallpur (13 inches) the eradication of weeds presents no difficulty.

So far as I am aware, these are the only systematic efforts that have hitherto been made to throw light upon the subject until I designed the series of experiments here described.

These experiments were started at Lyallpur Experimental Station in 1930 on perennially irrigated land of average quality which hitherto had been regularly cropped and maintained in clean condition.

For the sake of convenience all soil-inverted plots in the experiment are referred to as "ploughed plots", whilst non-inverted plots are referred to as "cultivated plots".

Three different aspects of the problem are being investigated in three separate experiments designated Sets A, B and C. The objects of each set are briefly described below:—

Set A.—In this case the yields obtained from ploughed plots are being compared with those obtained from cultivated plots; an equal number of operations being performed in each set of plots.

Set B.—In this case the yields obtained from plots are being compared with those obtained from cultivated plots; but in this case an equal state of tilth is aimed at in each set of plots irrespective of the number of operations performed in each.

Set C.—In this case the yields obtained from plots cultivated with improved implements and by improved methods are being compared with yields obtained from plots cultivated entirely with indigenous implements according to the ordinary zamindari practice.

In Set A an inverting plough is used for the first ploughing and subsequently only when the land becomes hard. After the original ploughing a horse hoe is used when necessary to stir up the land. The *desi* plough is used for an equal number of operations irrespective of whether the tilth produced is satisfactory or not.

In Set B the implements used are the same as in Set A, but the number of operations performed is different in each set of plots. Efforts are made to produce the same state of tilth in each set; so far as this can be judged by eye.

In all operations performed up to the sowing stage the ploughed and cultivated plots of both sets are treated as indicated above; thereafter they are treated alike as regards the kind and number of all cultural and other operations performed.

In Set C a combination of what is considered to be the most suitable improved implements is used with the object of producing a good state of tilth with the minimum expenditure of labour and time. The standard of cultivation followed in the zamindari plots is that of a selected zamindar resident in the neighbourhood of the Farm. His procedure is watched and followed throughout as far as possible; even to the time of ploughing, number of ploughings, method of sowing, number of intercultures, weedings, etc. The number of irrigations applied is the same in each case, though they may have been applied at different times.

The plots were purposely selected large, ¼th acre each, so that they could be readily ploughed or cultivated in either direction. Four

repetitions have been arranged with each treatment. The rotation followed is a common one of the locality, *viz.,* wheat, *toria,* cotton. The number of irrigations given is the same in all cases.

A record of the number of hours of man and bullock labour employed in each set of plots has been maintained; also a record of all operations performed in each plot.

Similar experiments have since been started at four other centres in the province where the climatic and agricultural conditions are somewhat different, but these have not yet been sufficiently long in progress to yield any useful information.

The experiment at Lyallpur is still in progress and it is hoped to continue it; but in the meantime sufficient data have accumulated to enable us to arrive at some conclusions as to the effects of the various cultural treatments given.

The statement appended gives the average yields obtained over the period of the experiment, from the different crops grown in each set, the number of hours of manual and bullock labour employed on each, up to the sowing stage, the cost thereof and the value of the produce obtained. The results obtained are discussed below under three different aspects.

Economic Aspect

The financial results of the different treatments are briefly summarised below. The profit (+) or loss (−) in rupees resulting from the use of improved implements is shown in each case.

	Wheat	Toria	Cotton	Average net profit per acre per annum in favour of ploughed plots
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Set A ..	+ 4 3 3	− 0 4 6	− 3 0 6	+ 0 4 0
Set B ..	+ 6 5 9	+ 0 1 9	− 5 14 3	+ 0 3 0
Set C ..	+ 8 14 0	+ 0 12 9	+ 12 8 9	+ 7 6 0

It will be observed from the figures in the last column that there is no apparent financial advantage in favour of the use of improved implements in Sets A and B where the standard of cultivation of both

Sets of plots was high. In Set C, however, the use of improved implements and better cultivation has resulted in a substantial profit.

Interest on capital, depreciation and cost of repairs on implements has not been taken into consideration, so the following additional sums must be debited to the ploughed plots in order to render the figures strictly comparative:—

	Per acre As.
Wheat	7·7
Toria	5·1
Cotton	5·1
Average	5·96

When the additional cost of the improved implements is deducted from the profits shown in column 5 there is no apparent financial gain from their use except in the case of the Set C plots.

Economy in Time and Labour

The use of improved implements has in all cases resulted in a considerable saving of time and labour as the following figures show:—

	Wheat				Toria				Cotton			
	Hours of labour saved				Hours of labour saved				Hours of labour saved			
	Man-labour		Bullock-labour		Man-labour		Bullock-labour		Man-labour		Bullock-labour	
	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.
Set A	19·6	29·7	19·6	29·7	14·0	30·6	14·0	30·6	11·2	24·6	11·2	24·6
Set B	14·9	21·7	14·9	21·7	12·1	21·1	12·1	21·1	10·6	19·6	10·6	19·6
Set C	8·6	13·3	8·6	13·3	6·9	15·3	6·9	15·3	2·6	6·9	2·6	6·9

The average saving in time and labour amounts to about twenty per cent.

Effect of Improved Implements on Yield

Detailed yields are given in the appended statement; those pertaining to each crop are discussed separately below:

Wheat.—In Set A where an equal number of operations have been performed with indigenous and improved implements the yields are practically the same.

In Set B the use of improved implements has increased yields by approximately 3·8 per cent. of grain and 3·3 per cent. of straw.

In Set C improved implements have increased yields by approximately 11·3 per cent. of grain and 10·2 per cent. of straw.

Toria.—In this case there is no significant difference between the yields obtained from plots under the various treatments.

Cotton.—In Sets A and B the cultivated plots have given higher yields by approximately 6 and 10 per cent. respectively.

In Set C the use of improved implements and line sowing has given an average increase in yield of 16·3 per cent.

General Observations

The inferences to be drawn from the experiment at the present stage seem to indicate that in a dry climate like that prevailing at Lyallpur where weeds are easily kept in check furrow-turning ploughs and improved implements are not required to the same extent as in areas of heavier rainfall, or where weeds are more abundant. The use of improved implements, however, results in deeper, better and cleaner cultivation and in a 20 per cent. saving in time and labour.

The work already done merely serves to emphasise the necessity of making a much wider study of the subject in different parts of the country under varying conditions.

Statement of Results

	Averages				Value of produce	Cost of preparatory tillage	Profit (+) or loss (−) in favour of improved implements
	Yield per acre		Hours of man-labour	Hours of bullock-labour			
	Grain	Straw					
			Wheat				
Set A	M. S.	M. S.	Hrs.	Hrs.	Rs. A. P.	Rs. A. P.	Rs. A. P.
1. Cultivated	25 18	56 25	66·0	66·0	94 1 0	12 6 0	
2. Ploughed	25 21	57 17	46·4	46·4	94 9 3	8 11 0	+ 4 3 3
Set B							
1. Cultivated	26 15	60 22	68·8	68·8	98 1 6	12 14 3	
2. Ploughed	27 14	62 22	53·9	53·9	101 10 3	10 1 3	+ 6 5 9
Set C							
1. Zamindari practice ..	17 24	41 4	64·5	64·5	65 10 9	12 1 6	
2. Improved implements ..	19 23	45 12	55·9	55·9	72 14 6	10 7 3	+ 8 14 0

Toria

Set A							
1. Cultivated	9 6	..	45·8	45·8	36 10 9	8 9 3	
2. Ploughed	8 17	..	31·8	31·8	33 12 3	5 15 3	— 0 4 6
Set B							
1. Cultivated	8 32	..	57·3	57·3	35 4 3	10 11 9	
2. Ploughed	8 11	..	45·2	45·2	33 2 0	8 7 9	+ 0 1 9
Set C							
1. Zamindari practice ..	8 28	..	45·0	45·0	34 13 6	8 7 0	
2. Improved implements ..	8 23	..	38·1	38·1	34 5 3	7 2 0	+ 0 12 9

Cotton

Set A							
1. Cultivated	10 23	..	45·5	45·5	84 10 6	8 8 6	
2. Ploughed	9 37	..	34·3	34·3	79 8 3	6 6 9	— 3 0 6
Set B							
1. Cultivated	11 28	..	54·0	54·0	93 11 9	10 2 0	
2. Ploughed	10 29	..	43·4	43·4	85 14 0	8 2 6	— 5 14 3
Set C							
1. Zamindari practice ..	9 7	..	37·5	37·5	73 8 0	7 0 6	
2. Improved implements ..	10 27	..	34·9	34·9	85 8 6	6 8 3	+12 8 9

Remarks:—The produce has been valued as under:

	Per maund Rs. A. P.
Wheat grain	3 0 0
Wheat straw	0 5 0
Toria	4 0 0
Cotton	8 0 0

The labour was valued as under:

	Per 8 hours Rs. A. P.
Hours of man-labour	0 8 0
Hours of bullock-labour	1 0 0

—*Agriculture and Live-Stock in India,* Vol. VII, Part II, March 1938.

Coffee Selection in the Netherlands Indies*

In the matter of selection of perennial crops such as coffee, rubber, cacao, cinchona, kapok, tea, the initiative was taken and most of the pioneer work has been done in the Netherlands Indies.

Selection of coffee was started some twenty-five years ago. Planters had indeed made a few feeble efforts before that time to improve their crops by selecting what they considered to be the best planting material, but their methods were inefficient and it was only after the Department of Agriculture and the Experimental Stations had taken the matter in hand and based selection on scientific principles that the work was carried on in a manner which promised satisfactory results.

The species mainly used in these selection experiments was *Coffea robusta,* which is the species most widely cultivated in the Indies at the present time. The once famous Arabian coffee (*Coffea arabica*) from Java, generally known to the trade as "Java coffee", has lost its commercial significance. During the nineteenth century it held first place as a product for export. About the middle of that century more than a million piculs (roughly 60,000 tons) was exported yearly. Then it fell a victim of coffee leaf-disease. This pest spread from East Africa all over Asia, devastating coffee plantations in Ceylon, where it appeared in 1867, and in Sumatra and Java, where it was first noted in 1876. No really practical means of controlling this disease has as yet been discovered. Planters simply had to abandon the cultivation of

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* By Dr. C. J. J. Van Hall in *Bulletin of the Colonial Institute of Amsterdam,* Vol. I, No. 2, February 1938.

arabica and replant their fields with other crops. At present not more than some 7,000 tons of "Java coffee" are exported yearly and the greater part of this comes from native plantations.

Between 1880 and 1900 much was expected from Liberian coffee, which had been imported by the Government in 1876. But this species, though at first it seemed immune against leaf-disease, also fell prey to this plague after a while, and gradually the fields became bare once more.

In 1900 another species, new to the Indies and so far unknown, was imported from West Africa and named *Coffea robusta*. It appeared to be much more resistant to leaf-disease than the Arabian and the Liberian coffee and it soon became popular on the estates as well as among native farmers. Larger and larger crops of it were cultivated year by year, until at present, it constitutes a most important product, the estates, especially in Java, producing more than 55,000 tons yearly and the native farmers, particularly in Sumatra, about the same quantity. About one-third of this quantity is consumed locally and roughly 80,000 tons are exported.

Like so many of our tropical crops this *C. robusta* is a heterogeneous mixture of a number of strains and any given plot will contain trees presenting widely divergent characteristics. For this very reason it may be regarded as an excellent object for experiments in selection.

This work has been taken up by the Bangelan Government Coffee Estates, the Central Java Experimental Station in collaboration with the Banaran Coffee Estate, the Malang Experimental Station, and finally the Besuki Experimental Station at Djember.

The method first pursued on the Bangelan and Banaran Estates is generally called "mother tree selection". It may be briefly described as follows: (1) Selection of mother trees showing superior qualities. (2) Propagation of these trees by vegetative reproduction (grafting) or by seed. (3) Testing of the offspring, both grafts and seedlings.

The first mother trees were selected at Bangelan by Dr. P. J. S. Cramer in 1907, and at Banaran by Caesar Voute in 1911. This work is less simple in the case of coffee than in that of other crops. The productivity of the mother tree is the first thing to be studied, but other qualities have to be considered as well, especially that of resistance to diseases and the size of the bean. Much painstaking and carefully supervised work has to be done before reliable information can be obtained regarding the productivity of the mother trees and the whole process has to be repeated, and the same difficulties faced, when the offspring of these mother trees have to be tested in their turn. The laboriousness of the work involved accounts for the fact that coffee selection has not become as popular with the planters as has,

for instance, the selection of rubber. In the case of rubber the procedure can be combined with the ordinary work on the plantation without causing very much extra trouble, but this is not the case with coffee.

Seedlings as well as grafts were used in studying the progeny of these mother trees. Grafts present obvious advantages: In their case there is only a mother tree involved and no father tree. Hence the progeny are uniform, being absolutely identical with the mother plant, at least in their hereditary characteristics. It is this fact which has led to propagation, by grafts or cuttings or buds—vegetative propagation as it is called—being the method generally adopted in the cultivation of most of our fruit trees and many of our ornamental plants. To have the plants uniform is a great advantage on a coffee estate when it comes to picking; for this means that the difficulty of having early-bearing trees interspread with late-bearing ones is avoided. Uniformity of the beans also makes preparation of the product for the market simpler. A further advantage of grafts is that, when we are obliged to deal with soils infected with eelworms (*nematodes*), they can be successfully grown on resistant seedlings as stock.

But grafts have also drawbacks. A coffee tree can produce only a very limited number of grafts per year and therefore propagation proceeds slowly. Then, the grafting technique complicates plantation work materially. Again the stock may influence the qualities, and especially the yield of the graft, which makes the selection of the right stock a problem itself.

The above considerations led experimentors to conclude that for testing the progeny of selected mother trees it was advisable to make use of both the vegetative and the generative methods of propagation.

The first experimental plots of grafted trees—each plot containing only the grafts of a single mother tree and thus representing a single clone†—were planted on the Banaran Estate in 1915, and at Bangelan in 1916. At Banaran there were thirty-two plots each carrying twenty-five trees. At Bangelan each plot had sixteen trees. In the course of time the number of selected mother trees at Bangelan has much increased and now there are more than 500 experimental plots of sixteen trees each under observation there.

As in the case of rubber, these experiments showed that only a few of the many trees selected for their high productivity produced offspring with a high yielding capacity. Many clones had to be discarded as not up to standard, or entirely worthless, and only a very small percentage was kept as being really superior.

When for the purpose of further study, larger plots of these high yielding clones were planted, a remarkable and at first disappointing

† "Clone" stands for all the graft-descendants of one tree collectively.

fact was observed: the yield per tree proved to be considerably less than that obtained from the smaller plots. The clue to the situation was found when the biology of the flower was studied and the fact emerged that the most clones are better adapted to cross-pollination than to self-pollination, in other words, trees of one clone are, generally speaking, most productive when fertilized with pollen from trees belonging to another clone. Not all clones behave alike, however, in respect to this matter of pollination. Some produce practically no seeds at all when self-pollinated, others—the majority—produce a small midiocre yield when self-pollinated but show a much higher degree of productivity when cross-pollinated. A very few yield satisfactorily whether cross-fertilized or self-fertilized.

The fact that almost all clones give a somewhat higher, or even a much higher yield when cross-pollinated has led planters to avoid planting large plots with a single clone. The general practice is to combine two or more clones, which have yielded satisfactorily when inter-crossed. A great deal of laborious experimentation was required to find these combinations. But the work has now progressed to the point where we may say that the really fruitful combinations of our best clones have been determined.

After the combinations had been determined another problem arose, namely, what is the best method of inter-planting? It was impossible to answer this question without first inquiring how pollen is carried from tree to tree under natural conditions. Until recently no one knew what role insects and the wind played in the fertilization of these plants. But investigations made of late years have shown that in a coffee plantation the number of insects that could possibly play a part in the fertilization is so inconsiderable that it is safe to say without further investigation that pollination of our *robusta* does not take place through their agency. Remains, then, the wind and it was J. P. Ferwerd's interesting experiments that taught us many facts regarding the details of the process. Glass plates were set up at different distances from coffee trees in bloom and covered with some sticky substance. It was then discovered by the deposits on the glass that a moderate wind will carry the pollen as far as one hundred metres and raise it to a height of at least eight metres. The results thus obtained put the question of interplanting on a stable basis.

As already mentioned, it is by no means a matter of indifference in the case of *C. robusta* what stock is used for grafting. Some twenty years ago, when selection work was still in its infancy, it was thought that *C. excelsa* was the ideal stock for *robusta* grafts. Later, preference was given to *robusta* itself as a stock. But it is now being proved that both species contain strains which make them suitable for use as stock for *robusta* clones. It has also become apparent that seedlings

belonging to the same species as the scion do not by any means always produce the best results as stock.

These results, obtained by much painstaking and difficult work in experimental gardens, are very encouraging, but we may not base direct conclusions on them as to the value of any given clone when planted on other estates. For experiment has shown that the behaviour of each clone varies with soil, climate and cultivation. For this reason the Experimental Stations always advise planters to make trial plots of more than one selected clone, for each planter has to find out for himself, which clones produce the best results on his particular estate.

On the Banaran Estate selection work was carried on by Caesar Voute, the manager of this estate, along the same lines as those pursued at Bangelan. But here there was no opportunity for research work and the selection had to be done in accordance with the kind of routine which could be followed on other estates as well. Some promising clones were obtained, as for instance, Banaran Nos. 4 and 7.

At Sumber Assin, the coffee garden of the Experimental Station at Malang, the selection was done by Dr. Hille Ris Lambers, of the Central and East Java Experimental Station. Results obtained there corroborated the view obtained at Bangelan that most of the *C. robusta* trees or clones are "self-incompatible", *i.e.*, give very little fruit when self-pollinated, and at this station as at Bangelan, data were collected bearing on the problem of how to combine father and mother trees so as to obtain the most fruitful pollination.

Very satisfactory results have also been obtained at the fourth institute which has taken up the selection work, namely, Besuki Station at Djember in the most easterly part of Java.

Some private estates have begun to follow the example of the experimental stations, selecting a number of mother trees and planting plots of grafts from these for experiment and study. Mention should be made in this connection of the Kalisanen Estate and the clones there grown, one of which seems particularly resistant to drought.

In the foregoing we have considered only the grafted offspring of mother trees, the clones. But it has been doubtful from the first whether "vegetative" propagation (by grafts in the case of coffee) or "generative" propagation (by seeds) would prove the more successful, and as both Bangelan and Banaran the two methods were tried. This "generative" selection has proved to be another very large field calling for laborious investigation.

During the first few years of selection work at Bangelan seeds were gathered from the mother trees without pollination having been controlled in any way. The offspring thus obtained was by an unknown father. At Banaran another method was followed. Here an effort was made to produce seeds by self-fertilization of the mother trees.

The advantages of self-fertilization are obvious, namely, that in the case of seeds produced by this method the superior mother tree becomes also the superior father tree and the trouble involved in artificial crossing is avoided. In order to achieve this self-pollination mother trees or branches thereof were put into cages made of mosquito-netting. The number of seeds obtained in this way was, generally speaking, small—very small indeed, in some cases. Since we have learned that many *robusta* trees yield only a small quantity of seed when self-pollinated, this result no longer surprises us.

It must not be supposed, however, that the quantitatively disappointing yield produced by self-fertilization necessarily involves seeds that will bring forth weakly or low-yielding trees. In a number of different cases "seedling families"‡ have, some of them, won excellent reputations among the planters. At Bangelan a number of such families were produced. These are not, like corresponding ones at Banaran, the descendants of single trees but of monoclone fields. Most of these fields are about two and a half acres in size, and hence the berries from trees in the middle of the plot are practically all the product of self-pollination.

Artificial crossing has also been used to produce a large number of "families". These have been kept under observation, each on its own plot, exactly like the clones or grafted offspring. Of these also the majority had to be rejected, but a minority produced seedling families that excelled in yielding capacity or in some other respect, or occasionally in all respects. Some families were quite uniform, others very heterogenous.

It is hardly necessary to say that the testing of the seedling families requires the same laborious care as the testing of the clones. Many different plots have to be kept under observation for a number of years before a reliable impression can be obtained about their productivity and other characteristics.

In the foregoing only *C. robusta* has been dealt with and this species is indeed the one which has been mainly studied. But it is not the only one to which scientists have devoted attention. The institute at Bangelan has always regarded it as one of its most significant tasks to import new species and varieties from other countries. This work was started as early as 1905 by Dr. P. J. S. Cramer, and it has been done so successfully that at present this station possesses a collection of different species of coffee which is quite unique.

Some of the most promising of these imported species have been used for inter-crossing and selection. A few of them may be mentioned here.

‡ The word "family" has been adopted to designate the whole offspring of a given father and mother tree.

Coffea congensis is the small-leaved species which possess the great virtue of being practically immune to the coffee-leaf disease but yields very poorly. It has produced hybrids by pollination by Uganda coffee, a variety of *robusta*. These hybrids have been given the name of *conuga*. Different *conuga* strains, descendants of selected mother trees, are at present under observation and several of the clones and seedling families seem quite promising. The *quillou* variety of robusta is very productive on some soils. Quillou Bgn. 121 may be mentioned as one of the superior strains. At Sumber Assin some good strains of *C. Canephora* have been obtained. This species is closely allied to robusta. The newly imported and little-known *kapakatu* coffee has also been used for inter-crossing.

In 1920 the Besuki Experimental Station took up the selection of Arabian coffee. What the scientists hope to achieve is the development of a pure arabica strain, more or less resistant to leaf disease and suitable for cultivation in regions where at present this is impossible, but the ideal they are striving for is still far from being realized. For, as a matter of fact, no tree with notably less than average liability to leaf-disease has yet been found. Another subject scientists have in view is to obtain a hybrid between Arabian coffee and some resistant species which shall combine some of the fine qualities of the Arabian with a certain resistance against leaf-disease. At Sumber Assin hybrids were obtained by pollination of *arabica* coffee with *C. laurentii* and one of these, Arla 1, seems promising. Hybrids have also been produced by crossing *C. arabica* and *C. congensis*.

Twenty years is a short time for selection work, especially when we are dealing with a perennial crop, and we have not yet come to the point where we can claim that the Experimental Stations have ready to hand clones and seedling families to suit the exact needs of any and every estate that may apply for advice and assistance. But for all that there is reason to look with satisfaction on the work so far accomplished. For thanks to the arduous and expert labours of different scientists there are a number of excellent clones and seedling families available for the planters to use as a basis for the individual experiments which each must inevitably make for himself on his own particular estate in order to discover which of various promising strains is best suited to the special conditions he has to offer. Planters have come to realize this and one may say that it is now the general custom with them to avail themselves of the selected material offered by the various institutions mentioned in the course of this article.

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Factors of Cotton Quality

BY

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What is quality in cotton? And how is the quality of a sample of cotton judged? Simple questions, yet, like many simple questions, far from easy to answer. All interested in cotton are fully aware of its infinite variation; some cotton plants are so only in name, for their seeds are truly naked, whilst others—Sea Island plants—have seeds bearing cotton fibres more than 2 inches long. Between these two extremes come the rest of the world's cottons, wild and cultivated, showing wide differences in every fibre property that can be either measured or estimated—length, grade, fineness, colour, bloom.... These differences between types are only a part of the story of variation. Even in a single type there is exceedingly great diversity in the several fibre properties; no two hairs of cotton have exactly the same conditions of growth, and would not therefore be expected to be identical in their fibre properties even in the absence of genetic variation. And when it is remembered that a single boll may contain half a million fibres, and that many factors influence the growth of a boll, wide variation in fibre properties in any commercial variety must be accepted as inevitable.

The variation among cotton fibres is emphasised because it is largely responsible for the difficulty of judging quality. The measurement of the fibre properties, instead of being made on a few fibres, has to be made on a multitude, and great care has to be exercised to see that that multitude is as representative as possible. So sampling demands consideration. It is by no means easy to select representative samples, though fortunately we are more statistically-minded nowadays, and are able to test the representativeness of our samples by means of the statistical tools invented for the purpose. But all this takes time; moreover, it adds to the complication of the problem, for we no longer have merely to gauge the effect on cotton quality of differences in length, hair weight, wall thickness, etc., but we have also to allow for the fact that the sample has a frequency distribution in each of these fibre properties, not one length, but many lengths, etc. True, we can denote the frequency distribution by additional statistics, but every new term in our equation for the expression of quality adds much to its complexity.

Even a single fibre is a complicated structure. Whilst it has only one length, its hair weight fluctuates along that length, as do most of its other physical properties; the convolutions vary greatly in their density of incidence, and often change direction; even the maturity differs at different parts of the fibre. Furthermore, the individual fibre

bears the impress of the cramped conditions of its growth within the boll in the form of innumerable abnormalities representing points of weakness.

In view of such widespread variation in any sample of a single variety it is not surprising that attempts to predict quality from measurements of fibre properties have not yet been crowned with success. They have been found on simplified versions of the facts. The fibre properties have been represented by single values, usually the mean values, so it is really remarkable that by these means it has been found possible to account for over 80 per cent. of the variation in quality, as indicated by the spinning value.

Mention of spinning value as a measure of quality brings us back to our opening question: What is quality? Undoubtedly cottons are ultimately judged by the quality of the goods made from them. Assuming that the housewife is an infallible judge of the quality of the cotton goods she buys when shopping, we should be able to classify our cottons by reference to the prices commanded by these goods, or more exactly, by the prices paid for the yarns from which these goods are made, making due allowance for the spinning and ancillary costs.

In a general way this is no doubt true, largely because experience has been gained of the different cotton growths which have established reputations in the world's cotton markets. The fact that a particular lot of cotton has been grown in a certain place plays a large part in the fixing of its price. Quality is identified within limits with place of origin; in this way past experience is wedded to present production. Working within the aforesaid limits associated with any particular place of origin, an expert grader has no difficulty in assessing the value of any particular lot of cotton with a high degree of accuracy. He makes a hand-and-eye examination of samples for the following properties in their order of importance: (1) length; (2) grade or leafiness, including colour and any bloom or lustre associated with it; and (3) character, including strength, drag, hardness or softness.

In dealing with a delivery of say, 2,000 bales, he examines the first few bales for these different properties, taking a number of pulls from the sample from each bale. He thus quickly arrives at a conception of how the cotton is running, and is then able to proceed rapidly with the classing of the remainder of the bales both for grade and staple. In the height of the season an expert cotton classer in the United States is often called on to judge in this way some 1,000 bales a day. Cotton brokers in other markets class their cottons equally rapidly when necessity demands. It will be seen, therefore, that this hand-and-eye method has a tremendous advantage in speed of performance. Some such method would seem to be essential for success in carrying on the activities of the trade in raw cotton, with last year's

record world crop amounting to nearly 40 million bales, especially when it is recollected that each bale often passes through many intermediaries, each of whom makes his own tests for quality.

This trade method of judging the quality of cotton does fulfil its purpose; the trade in the vast cotton crop is carried on with the necessary expedition, and it does serve the various interests concerned in a generally satisfactory manner. On the other hand, the method suffers from certain limitations. As already mentioned, the success of the system turns on a knowledge of the place of origin of the cotton and experience of the types of cotton grown there. If, therefore, a new type is bred having characteristics widely different from those which distinguish the type identified with that particular place, there is grave danger that the new variety will be treated as if it came within the limits which tradition and experience have imposed on the old. Such cases are by no means imaginary, as the following examples will suffice to show.

Certain spinners in Bombay, when first turning their attention to Peruvian cotton, were greatly mystified by the fact that in spite of its considerable length it proved a relatively poor spinning cotton. They expected it to spin much better than Punjab-American 289 F, but found that it did not do so; they were unfamiliar with the Peruvian cotton and ignorant of its comparative coarseness. Another spinner unfamiliar with the varied types of cotton produced in West Africa was much disappointed to find that a cotton which had a long staple and pulled well did not give him the yarn that he expected and which he had contracted to deliver; the West African cotton happened to be the coarse Ishan cotton instead of Northern Nigerian, of which alone he had had previous experience. Failure of human judgment in both these cases arose immediately from lack of experience of the type, though fundamentally the difficulty is one of assessing the relative fineness or coarseness of a cotton by sight or touch.

The trade method of valuing a sample of cotton affords a striking contrast with the laboratory method. The "combined stapling test" in use at the Shirley Institute for judging the quality of staple measures three characters: (1) length; (2) fineness; and (3) maturity. The time taken by a single observer in making one combined stapling test is from two to three hours; for accuracy every sample is tested by at least two observers. The quantity of trash or foreign matter present is found by means of the Shirley Analyser, the principle of which takes advantage of the difference in buoyancy of the open lint and the trash by first completely opening the lint by means of a saw-tooth-roller (known as a taken-in type of beater) then projecting the whole into a stream-lined air-flow of narrow depth in which the cotton hairs are

buoyant, whereas the trash falls through; the lint is collected on a perforated cage and the trash in a convenient settling chamber. These laboratory methods are, of course, more objective than those used in the trade. It will be seen that there is a general correspondence between the properties measured in the two cases if we identify "character" with hair weight and maturity. But the laboratory methods take no cognizance of colour and bloom, and it is rather doubtful whether they always give an indication of bad character in a cotton.

It may be added that investigations of the relation between fibre properties and spinning value have thrown considerable light on the relative importance of length and fineness. For cottons up to 1 inch long, length is of outstanding importance; for longer cottons, fineness becomes of increasing relative importance; and for very long cottons a much greater change is produced in spinning value by a slight change in hair weight per centimetre than by a similar change in length. Fortunately, there is a strong correlation between the length and fineness more than the length that is directly responsible for good spinning performance, yet through its correlation with fineness the length still remains quite a good general measure of quality. This is a happy accident seeing that the reverse correlation holds good for wool and other fibres, which have length associated with coarseness. However, the correlation between length and fineness of cotton is by no means invariable, as the existence of the long coarse cottons, Tanguis and Ishan, shows: and the incompleteness of the association acts as a valuable spur to the cotton breeder, who knows that he may still hope to discover fine cottons among his strains that are not over long.

We may now apply these considerations of present-day techniques to attempts to introduce new types of cotton. Certain questions at once arise. First of all, will its agricultural properties render the new type advantageous to the grower if its quality proves satisfactory? Next, what is its quality? What is the grader's judgment on it? What do the results of the combined stapling tests reveal? And, finally, how does it spin and what sort of yarn can be made from it? The last question expresses implicitly the view that yarn quality is the measure of cotton quality. As a measure of the intrinsic quality of a cotton the spinning test has, in fact, found wide acceptance.

At first sight the spinning test is a much more complicated method of judging the quality of a cotton sample than either the Grader's method or the laboratory measurements of the fibre properties. In it the sample may pass through sixteen or more machines, several of which have to be set with special regard to the particular sample; and the quality of the yarn has still to be determined before judgment is pronounced on the quality of the cotton. It might, therefore, be

thought that the spinning test is subject to even more arbitrary judgment than the inspection of the cotton, and that it introduces more variables than fibre testing. Nevertheless, cotton is bought and sold to undergo spinning, so the spinning test is a "practical test", and experience proves it to be the best guide available to the results of commercial spinnings. It has indeed been long accepted as the best measure of the quality of new cottons produced by the officers of the Empire Cotton Growing Corporation, this work having been centred at the Shirley Institute for many years past. Spinning tests have similarly been carried out on long staple and other cottons by the Research Laboratories of the Fine Cotton Spinners' and Doublers' Association, Manchester; on Indian cottons at the Indian Central Cotton Committee Technological Laboratory in Bombay; on American cottons in College and other laboratories working under or in collaboration with the United States Department of Agriculture; and recently on Egyptian types of cotton at the Spinning Laboratory at Giza.

Special techniques have been worked out for these spinning tests which are generally based on the results attained by processing 10 lb. or even 5 lb. of cotton on spinning machines of the standard type used in the industry. The cotton sample is spun to various counts of yarn with standard twists and under standard conditions, and these yarns are tested for strength and examined for appearance. The test for strength is largely objective; but it has not yet been found possible to exclude the subjective element from the judgment of appearance. However, the fact that the cotton can be spun at all in an economic manner to certain "highest standard warp counts" is itself at once a very valuable index of the quality of the cotton; still, those features which contribute to the yarn appearance—its neppiness, levelness, colour, and hairiness—constitute most important elements of quality in the yarn and therefore in the cotton. Neppiness is a particularly undesirable feature; it is sometimes, but not always, associated with immaturity, and neps due to entanglements of immature hairs are anathema to the merchant, since the appearance of an otherwise excellent cloth may be completely ruined, such neps often showing up most unpleasantly in self-coloured fabrics.

"Process neps"—those consisting of mature hairs bundled together in the processing through the machinery, and presumably due to inefficient action of the machinery—would not show the same ill-effect in dyeing. Nevertheless, they disfigure the appearance of grey and bleached clothes, especially when magnified by a calendar finish often given to these clothes; such neps must, therefore, be regarded as detrimental, though this defect cannot rightly be laid at the door of the quality of the cotton. Such process neps should not occur in the

spinning test, in which the machinery and the processing should evidently be the best possible.

A point of some difficulty arises in connection with "dead neps" or "mixed neps", which owe their inception to dead or immature hairs; whilst such neps, when they occur, must be attributed to dead hairs in the cotton, the converse does not hold good, for some immature cottons give yarn that is practically nep-free. Unfortunately, at the moment, there is no means of predicting from an examination of the cotton itself whether an immature cotton will or will not give rise to dead neps in the yarn.

Another feature detrimental to the appearance of the yarn, is the presence of small leaf and seed particles. Although the majority of the impurities are successfully removed by the cleaning machines in the spinning sequence, cotton that is very trashy in the raw state cannot ordinarily be cleaned to the same pitch as cotton that is comparatively clean at the outset; the yarn shows the impurity of its origin, and the cotton is depreciated accordingly. The limitations of climate or geography cannot be entirely circumvented, but where these lead to difficulties in picking the cotton clean, it is evident that those varieties which give the least trouble in this respect are to be preferred.

After a new type of cotton has done well in the spinning test, what next? If it is satisfactory agriculturally, there comes the problem of getting it taken up by the cotton market and the spinner. It has to run the gauntlet of trade appraisement, and some natural psychological resistance to the impact of a new type must obviously be expected. Arriving on the market as a new cotton from a known cotton-growing area, it will almost certainly be valued in terms of the other growths from the area; and if it is of the same general type an improved derivative of a standard growth, particularly if the improvement is in the direction of longer staple—the new cotton is likely to receive a welcome and due recognition of its worth. On the other hand, if the new cotton is out of character with the well-known growths of the area, more difficulty is likely to arise in obtaining a true monetary appreciation of its value, and a longer time will elapse before it finds its feet in the cotton market. The spinner has to be convinced that the new growth will suit his particular qualities of yarn as satisfactorily as the type he is called on to relinquish. He is rightly somewhat suspicious of the "parvenu" cotton. Even if he does find it satisfactory technically, he wonders whether sufficient supplies will be available for him to be able to place the yarn continually on offer. The only thing he knows for certain is that the new cotton invites him to submit to the hazards of the unknown; he has to balance a problematical small gain against a possible large loss.

In a large mill of say, 100,000 spindles, changing over from one type of cotton to another demands considerable organization, as all the machines have to be kept constantly supplied with cotton in order that production may not suffer. In a fine spinning mill a fortnight may elapse before the cotton which is taken into production in the cotton room is removed from the spinning mule as spun yarn. And if the decision to go on to a new cotton is acted on, but turns out ultimately to have been an "error of judgment", the resulting financial loss is bound to prove considerable. Of course, every precaution would be taken against such a contingency by using the new type on only a part of the machinery in the first place.

It is perhaps a fair summing-up of the present position to say that as far as the short and medium staples are concerned the improvement in cotton quality likely to prove immediately the most remunerative to the grower is one of staple, as it is certainly easier to obtain a premium for greater length of staple than for any other improvement in quality. Apart from a greater cleanliness where possible, the next desideratum is the avoidance of neppiness. It is an advantage if the new type is in line with the old; it should not only be good in spinning, but also appear good to the eye and hand. A good broker's report forms a useful passport to the cotton in its passage from the grower to the spinner; the hand-and-eye method of examining cotton is not likely to lose its place as the day-to-day method of dealing with the cotton crop on its way from the producer to the user. On the other hand, the tests of fibre properties and the spinning tests have not only become the tests *in excelsis* for assessing new cottons, they have also found a very definite and highly useful niche as supplementary and even crucial tests which many firms use with profit. These physical tests have their proper place as a kind of "Court of Appeal"; whilst they cannot rival the hand-and-eye method for speed, they alone make it possible to obtain, season after season for any particular growth, objective records which can be duly preserved and which become increasingly useful as they accumulate. It is by means of these and other physical methods that full understanding of the relation between the properties of a cotton and the processes of spinning will, it is hoped, ultimately be won.

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